



## Use of Constructed-Response Questions to Support Learning of Cell Biology during Lectures<sup>†</sup>

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### INTRODUCTION

Classroom response systems such as clickers (2) can help promote active learning during large-class lectures (4, 8, 9, 10). While the use of clickers was well-received in my modules (16), the numeric keypad clickers restricted question formats to either multiple-choice questions (MCQs) or True/False questions.

MCQ-based assessments are common in large-class modules, given their cost-effectiveness (12). Consequently, students in large cohorts are often exposed to MCQs in learning and assessment settings. However, MCQs with accompanying cues might give students the impression that assessments are less than challenging (14), and could lower students' chances of developing higher-order thinking skills. Furthermore, it is not easy to design good MCQs to evaluate student learning reliably (3, 6). This has implications for large classes that generally have fewer opportunities for students to practice constructing their answers.

To reduce our over-reliance on MCQs in assessments, we had included essay assignments in our second-year undergraduate Cell Biology module, with individual feedback provided for each essay (17, 18). With 300 students, however, it was impossible to give more than one major essay assignment per lecturer and provide sufficient feedback to students throughout the module.

I therefore incorporated constructed-response questions to encourage students to synthesize answers in their own words during my Cell Biology lectures, where I can provide formative feedback to their written responses. These questions were designed to promote active and collaborative learning (15) and help students learn to construct knowledge on their own (16).

Here, I describe my experience converting MCQs to constructed-response questions for in-class learning activities by removing cues from the MCQs. From the responses submitted, students seemed capable of providing answers

without the need for cues. Using class-response systems such as Socrative for such constructed-response questions could be useful to challenge students to express their ideas in their own words. Moreover, allowing students to construct their own answers could reveal misconceptions, which then could be corrected in a timely manner.

### PROCEDURE

#### Use of Socrative

The beta version of Socrative (<http://beta.Socrative.com/>) is a free, web-based classroom-response system that easily allows for the design of constructed-response questions. Socrative can be accessed by students and teachers via any Internet browser using any mobile device. Most of our students carried a smartphone, tablet, or laptop to class. Students without devices were encouraged to work with classmates to come up with answers for submission. Internet access was provided through the university's Wi-Fi system.

To use Socrative, the teacher signs up for a free account and is assigned a classroom number. In this virtual classroom, the teacher can design and save quizzes comprising different types of questions before or during the lessons. The quizzes can be started via the website any time during a lecture. Once the quiz is started, students can enter the classroom number on the Socrative website to access the quiz questions. Students key their answers into the space provided beneath each question and their submitted answers per quiz are collated by Socrative. The answers can be projected in class for everyone to read. As student responses were anonymous, they answered freely. The free Google Forms is another good alternative (data not shown).

#### Constructed-response questions and students' responses

I converted clicker MCQs used in last year's teaching slides (Appendix 1A) to constructed-response questions by removing the cues provided (Appendix 1B). Interestingly, students' constructed answers (Appendix 1C) shared similarities with the cues provided previously for the questions (Appendix 1A).

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This approach further allowed me to see a range of students' answers that I would not have seen using MCQs. These answers opened up discussions on various issues during and after classes. For issues directly relevant to my lectures, I responded in class to clarify students' ideas and understanding. The answers also revealed unexpected misconceptions that I immediately discussed with students (Appendix 2). As students submitted answers on a voluntary basis, the number of respondents was inconsistent throughout the module. Nonetheless, the answers from a segment of students were sufficient for others to view the different thoughts and ideas of their classmates.

### After-class feedback on students' answers

After each quiz, Excel reports containing the questions and students' answers could be downloaded. After class, I included further written comments in the Excel files on issues on which I lacked time to elaborate during lectures (Appendix 2). The edited reports were then uploaded onto our Integrated Virtual Learning Environment (IVLE) for students. I could therefore provide formative feedback on a range of typical answers fairly easily. The Excel files were also convenient for providing additional explanations on interesting answers that went beyond the scope of my lectures for students wishing to learn about topics outside the planned curriculum.

Of the 63 students (21%) who responded to the end-of-semester survey, most of them viewed the approach favorably (Appendix 3). Notably, they found reading other classmates' answers useful for learning from one another (Appendix 3B). Although only half the respondents had prior experience with clickers, there was no statistically significant difference between these students and those who had not used clickers before (Appendix 4A) in terms of difficulty in answering the short-response questions, indicating that there were no barriers to using such questions. Of the respondents with no prior experience with clickers, 71% indicated constructing answers on their own was useful, compared with 53% of those who had, although this was not statistically different (Appendix 4B). Crucially, the respondents regarded receiving feedback in class to written answers as important (Appendix 4C).

While this approach has advantages (Appendix 5), the respondents also raised concerns including insufficient time to upload their answers (Appendix 6). This was sometimes due to Wi-Fi connectivity problems leading to a lag time in receiving students' responses. Such problems can be overcome with better management of time on my part and preparation on the use of an online response system on the students' part.

### CONCLUSION

Incorporating constructed-response questions in class with feedback could support active-learning (I, II), which

is known to be more beneficial than the passive learning of traditional lectures (2). Providing students with opportunities to compose their own answers is critical, given the links between writing and learning (5, 7), as students move from "knowledge-telling" to "knowledge-transformation" (13) by constructing answers. Constructed-response questions could be used during lectures to promote scientific writing and stimulate students' thinking, and the format can be incorporated in large-class lectures.

### SUPPLEMENTAL MATERIALS

- Appendix 1: Example of a short-answer question
- Appendix 2: Example of an Excel report
- Appendix 3: End-of-semester student feedback
- Appendix 4: Students' perceptions of the constructed-response questions
- Appendix 5: Advantages of constructed-response questions
- Appendix 6: Disadvantages of constructed-response questions

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